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A contribution to taxonomy and biology of *Spalerosophis diadema diadema* (Schlegel, 1837) along with a new record of *Spalerosophis atriceps* (Fischer, 1885) from the Poonch District of Jammu and Kashmir, India (Reptilia, Squamata, Colubridae)

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Abstract

The present study is aimed to validate the occurrence of two species of Diadem or Royal snakes of Genus *Spalerosophis* Jan, 1865 from the Poonch District of Jammu and Kashmir, India along with the presentation of eight different colour morphs and diagnostic characteristics. The eight different colour morphs include four colour morphs of adults of *S. d. diadema* (Schlegel, 1837), two colour morphs of adults of *S. atriceps* (Fischer, 1885), one colour morph of subadults of unknown parentage and one colour morph of the adult of *S. diadema* (Schlegel, 1837) represented by a single individual whose identification at subspecies level (ssp. *cliffordii/diadema*) is the subject for further investigations for want of more specimens. This solitary specimen shares many similarities with *S. d. diadema*, but it has less number of sub-caudal scales which point towards the likelihood of *S. d. cliffordii* (Schlegel, 1837). The distribution, activity, habitat and behaviour have also been reported along with the morphological, morphometric and meristic characters. Between two identified species *S. atriceps* is a new report from the Poonch District. Reported specimens are mapped across the study area and are depicted here in the distribution map.

Key Words

Colour morphs, taxonomy, *Spalerosophis atriceps*, *S. d. diadema*, Pir Panjal, Poonch, Western Himalayas

Introduction

Genus *Spalerosophis* Jan, 1865 of the family Colubridae has a very large range of distribution in arid and semi-arid regions from North Africa in the west through Arabia, Iran and Pakistan to central India in the east (Marx 1959; Minton 1966; Mertens 1969; Gasperetti 1988; Whitaker and Captain 2004, 2008, 2015; Sharma 2007; Schätti et al. 2010; Sindaco et al. 2013; Uetz 2015; Yadollahvandmiandoab et al. 2018). The systematics and taxonomy of *S. diadema* (Schlegel, 1837) from the Euphrates and the Caspian Sea to the Indian subcontinent need clarification (Schätti et al. 2010). The probable reasons behind the confusion in the identification of *Spalerosophis* spp. are: the different counting of scales of the head, printing lapses and different descriptions of supranumeral scales in the pileus region, particularly the prefrontals (Dumeril et al. 1854; Gunther 1864; Zugmayer

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1905; Schmidt 1930; Marx 1959; Minton 1966; Baig and Masroor 2008; Schätti et al. 2010). In present study, labelled sketches of scales of the pileus region (Fig. 1) and different arrangements of prefrontals (Fig. 2) have been given to avoid confusion and misinterpretation.

Minton (1966) reported that the Indo-Pakistan segment is represented by *Spalerosophis arenarius* (Boulenger, 1890), *S. diadema diadema* (Schlegel, 1837), *S. diadema schirazianus* (Jan, 1863) and *S. atriceps* (Fischer, 1885). *Spalerosophis atriceps* was considered a species of its own by Minton (1966), Baig and Masroor (2008), Schätti et al. (2009, 2010), Whitaker and Captain (2015) and colour morph of adult *S. diadema* by Marx (1959), Mertens (1969) and Khan (2006). In the present study, we too have considered *S. atriceps* as a valid species. Within the Indo-Pak region, *S. d. schirazianus* was shown distributed along Iran, Afghanistan and western India, *S. arenarius* from Gujrat and only *S. d. diadema* was shown with a little wider range of distribution from the central, north and north-west part of India (Marx 1959). Baig and Masroor (2008) considered *S. schirazianus* as junior synonyms of *S. diadema.* Following Marx (1959), Schätti et al. (2009) reported *S. diadema* as a polytypic species represented by *S. d. diadema* and *S. d. cliffordii*, the latter from Iran. Marx (1959) separated the *S. d. diadema* and *S. d. cliffordii* based on the number of subcaudals, i.e. 80 or more in *S. d. diadema* versus less than 80 in *S. d. cliffordii*. In our study, we followed the determination key given by Schätti et al. (2009) for the genus *Spalerosophis* Jan, 1865. Working on the herpetofauna of Jammu and Kashmir, Sahi and Duda (1985) have shown the presence of *S. d. diadema* from districts Kathua, Jammu, Dumel, Udhampur, Reasi, Poonch and Ramban; *S. atriceps* from districts Kathua, Udhampur and Kishtawar and *S. arenarius* from districts Jammu and Bhaderwah. In the literature, we have not found any mention of *S. d. cliffordii* from India. It is, for this reason, we kept a specimen representing a subcaudal count of less than 80 (resembling *S. d. cliffordii*) for further investigations. Schätti et al. (2009) reported that the occurrence of *S. diadema* from north-west India (Kashmir) requires serious investigations. The lack of knowledge of the reptilian fauna of Jammu and Kashmir in general and the current study area (i.e. Pooch District which is located in the Pir Panjal range of Western Himalayas) in particular is supposed to be mainly caused by the remoteness of the area and by the area's instability since the 1990s owing to its location near the border of Pakistan. The presence of *S. diadema* in India was put in question for investigations and confirmation by Schätti et al. (2010) due to the absence of its mapping by Baig and Masroor (2008) and due to reporting based on subadult specimens. In the current study, the occurrence of *Spalerosophis* spp. from different localities of the study area has been mapped (Fig. 3) besides reporting on adult individuals along with their diagnostic characteristics (Table 1). In addition, we are presenting a new report on the occurrence of *S. atriceps* along with revalidation of the occurrence of *S. d. diadema* from Poonch District of Jammu and Kashmir, India. *Spalerosophis* spp. are represented by different colour morphs both within the species and between its different species which has led to great confusion in identification (Baig and Masroor 2008). Here, we are reporting eight colour morphs of the genus *Spalerosophis* Jan, 1865 spread across three species under discussion. These findings will confirm the distribution of these species from north India, in general and Poonch District of Jammu and Kashmir, in particular, besides supplementing the diagnostic characteristics for identification.

Materials and acronyms

On sighting the specimens in the field, the activity of the snake, time, date, climate, coordinates, photographs and videos have been taken. The threatening behaviour of *S. d. diadema* has been recorded in captivity. Specimens which were found dead on the field were preserved in the Mendhar College Museum of Zoology (MCMZ) for reference. Different localities of Poonch District from where 56 specimens belonging to genus *Spalerosophis* have been reported during the years 2019–2021 (Fig. 3) exhibit 8 different colour morphs (Figs 4–7). The meristic and morphometric characters of 12 collection-vouchered non-types, including two photo vouchers and ten vouchered specimens are shown in Table 1. Out of 12 preserved specimens, MCMZ0619 is a subadult of unknown parentage (*diadema/atriceps*, Fig. 5A), eight specimens belong to *S. d. diadema* (Figs 5B, C, 6A, B), one male specimen (MCMZ0119) of *S. diadema* remains unidentified at the level of subspecies viz. *cliffordii* or *diadema* (Fig. 6C) and two specimens belong to *S. atriceps* (includes one male, MCMZ0920 and one female, MCMZ1020) (Fig. 7).

Terminology used for describing meristic and morphometric characters (Figs 1, 2, Table 1)

To avoid terminological confusion while interpreting the number of head scales, we give labelled head sketches in Figs 1, 2. While counting the number of scales even a small granule has also been taken into account. 'Anterior scale rows -asr' denote anterior dorsal scale rows counted one head-length behind the head excluding the ventrals. 'Mid-body scale rows -msr' are the dorsal scale rows counted at the level of the mid-ventral scale, excluding the latter. 'Posterior scale rows -psr' refers to the dorsal scale rows one head length anterior to the anal plate, excluding the ventrals. 'Anterior temporal -at' is a vertical row of scales immediately behind the postocular touching below the supralabials and above the parietals. 'Circumocular -co' is a ring of scales in contact with the eye (i.e. 'preocular-pro' + 'subocular-so'+ 'postocular-po' + 'supraocular-spo'). 'Dorsal blotches - db' are mid-dorsal large dark spots running behind the head down the tail. 'Frontal-fr'

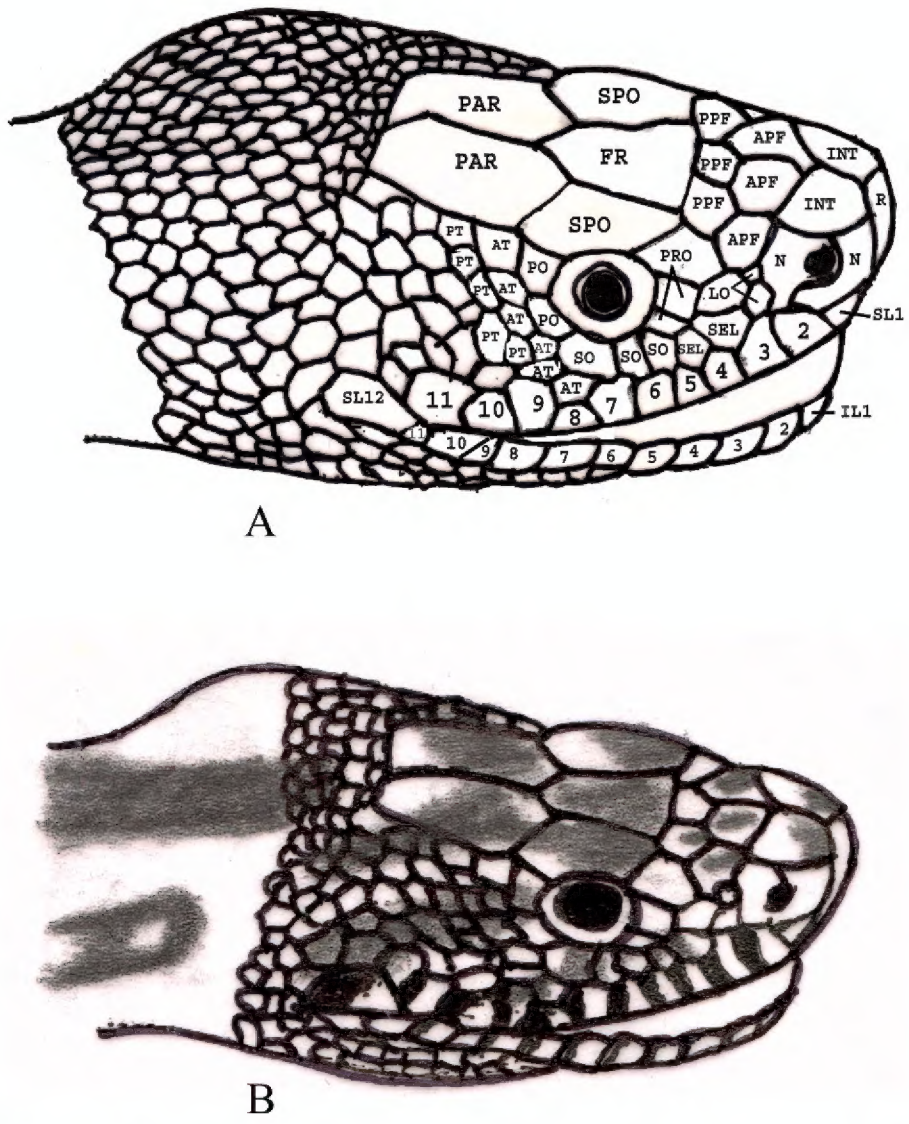

Figure 1. A, B. Dorsolateral sketch of head of *Spalerosophis diadema diadema* (MCMZ0314). **A.** The characteristics head scales pattern and nomenclatures used for *Spalerosophis* spp. under report; **B.** The characteristic black markings on supralabials scales found in *Spalerosophis* spp. under report.

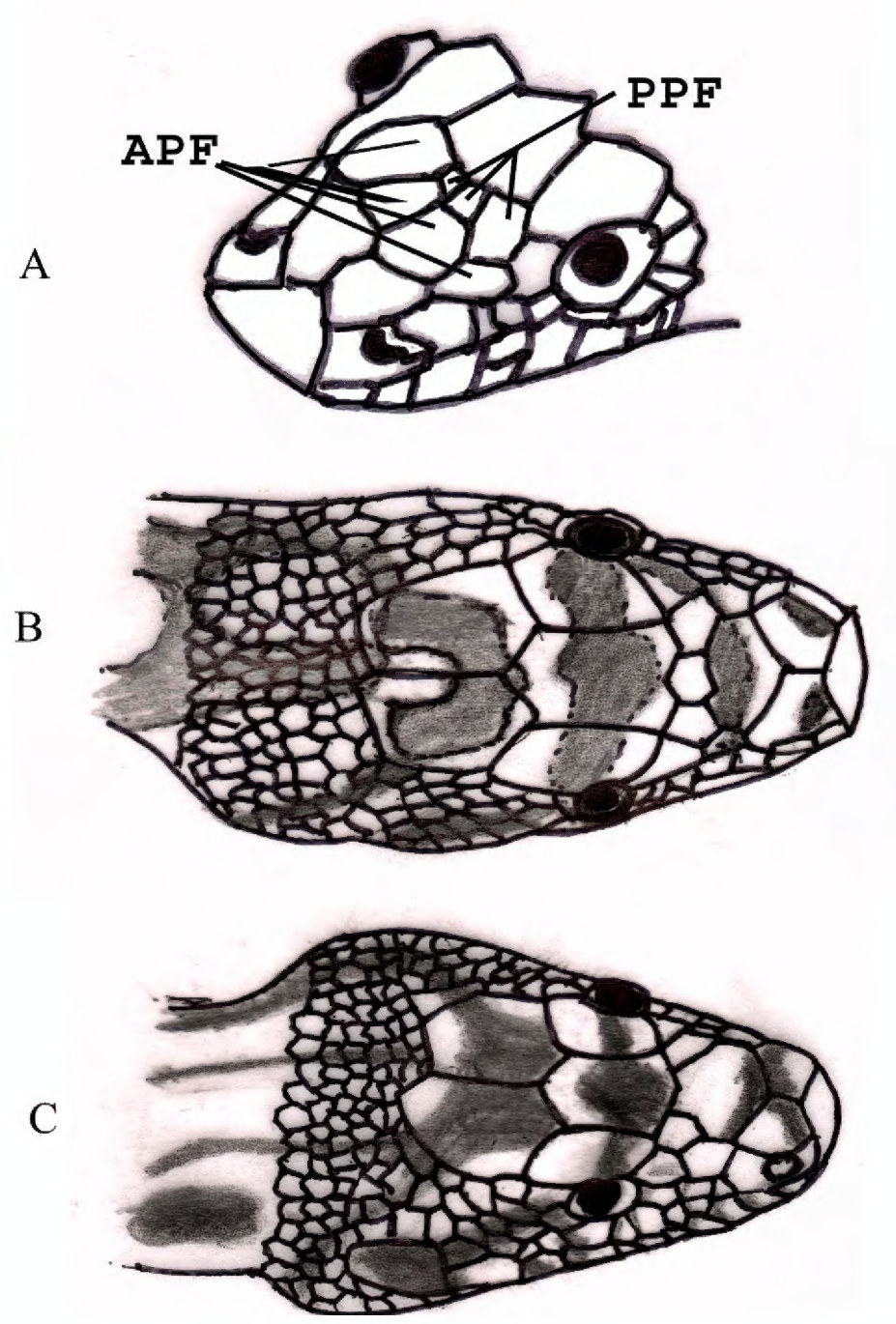

Figure 2. A–C. Showing the variations in the arrangement of the head scale of *Spalerosophis* spp (*diadema diadema/ atriceps*) with a special focus on prefrontals. **A.** MCMZ0119; **B.** MCMZ0819; **C.** MCMZ0514.

is the large scale present on the dorsal side of the head, between the eyes and adjacent to the supraocular. 'Infra labials -il' and 'supralabials -sl' are scales of the lower lip and upper lip, respectively. 'Internasals-int' are the scales along the dorsal side of the snout connecting the nasals on both sides of the head. 'Loreals -lo' are the scales situated on or above a straight line parallel to the mouth from the lower posterior tip of the nasal to the circumocular ring and below the prefrontals. 'Prefrontals -pf' are the scales on the dorsal side of the head, often arranged in two rows, between 'internasal-int' at their anterior and 'frontal-fr' at their posterior, bordering laterally with loreal and preocular. 'Anterior prefrontals-apf' is the horizontal row of prefrontal scales touching internasal anteriorly, while 'posterior prefrontals- ppf' is the horizontal row of prefrontal scales touching frontal and supraocular posteriorly. 'Secondary labials - sel' are the scales below the loreals, anterior to scales of the circumocular ring and in contact with the supralabials. 'Rostral-r' is the single scale present at the tip of the snout. 'Ventrals - vent' are the scales counted from the first transverse scale on the ventral side of the head just posterior to the gular up to the anal plate. 'Anal - an' is the last ventral scale covering the anal opening. 'Sub-caudal -scd' are the scales on the ventral side of the tail. 'Temporals' are the scale rows present on the sides of the head immediately behind the postocular, between the parietal above and supralabials below. A vertical row of temporals present adjacent to the postocular is 'anterior temporal- at' row and a vertical row of temporals present posterior and adjacent to anterior temporals is 'posterior temporal- pt'. 'Parietal- par' are the two large scales present on the head connected to the posterior margin of the supraocular and frontals. If the left and right counts are different, they are separated by a slash.

Results

The *Spalerosophis* spp. in the study area are represented by a moderately large population. A total of 56 individuals have been reported from different locations of study area during the years 2019–21, out of which three individuals represent *S. atriceps*, 47 individuals represent *S. d. diadema*, five individuals represent subadults of unknown parentage (*S. d. diadema/S. atriceps*) and one specimen represent *S. diadema* whose identification at subspecies level is subjected for further investigations. Observed specimens have shown distinctive colourations and markings on the body. Common characteristics features shown by all three species under report include: (1) an elongated and oval head well-demarcated from the neck; (2) long and moderately obtuse snout; (3) eye with a round pupil and golden iris;

(4) rostral broader than high; (5) orbit surrounded from all sides by a ring of ocular scales (Figs 1A, B); (6) prefrontals and loreals broken into small scales (Figs 1A, B, 2A–C); (7) a high number of temporal scales (4–6 in the first row) (Fig. 1A, B); (8) one undivided sub-pentagonal frontal; (9) parietals two, not in contact with postoculars; (10) divided nasals; (11) two inter-nasals; (12) posterior dorsal scale rows 19–21; (13) each supralabials scale with a vertical dark marking /band on the posterior margin (Figs 1B, 4A–J); (14) white underside of the head and chin (Figs 5–7 ventral); (15) an entire anal plate and (16) round tail which is shorter in males as compared to females.

Morphology (Figs 4–7)

Body colour, markings and blotches. The genus *Spalerosophis* shows a great variant of inter- and intra-specific colouration, markings and blotches.

Colours and markings of subadults of unknown parentage are more or less similar with that of adults of *S. d. diadema* but not with the adults of *S. atriceps*. Out of 56 individuals observed in the present study, five were subadults with a grey background colour of the dorsal body (Fig. 5A). A total of 47 adults of *S. d. diadema* have a background colour of the dorsal body from dark brown (Fig. 5B, C) to ruddy brown (Fig. 6A, B dorsals) with five rows of large darkish spots (blotches) quincuncially arranged passing down the back from the nape well on to the tail. Spots on the median row are large, rounded or rhomboid in outline alternating with the two rows of smaller spots on each lateral side (Figs 5, 6). *Spalerosophis diadema cliffordii/ diadema* (MCMZ 0119) also has

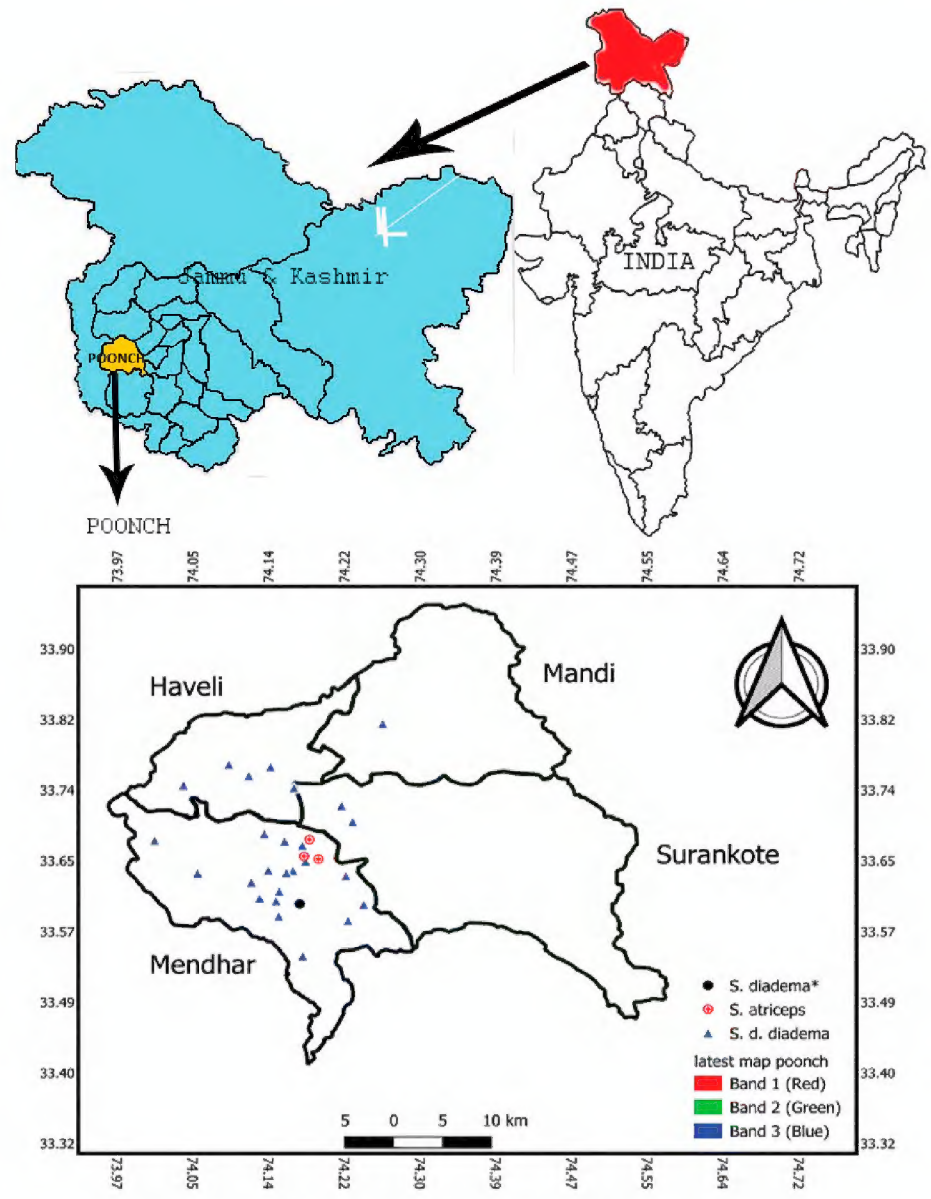

Figure 3. Map showing the distribution of *Spalerosophis* spp. in the study area (Poonch District). * Identification at the subspecies level (*cliffordii/ diadema*) is yet to be ascertained.

ruddy brown body colour with a similar pattern of spots as depicted by *S. d. diadema*, except that the spots are restricted to a group of 4–6 scales and it seems that the spots are being created by grouping of dark scales (Fig. 6C).

Table 1. Morphometric and meristic characters of *Spalerosophis diadema diadema*, *S. d. cliffordii/diadema* and *S. atriceps*. Abbreviations: **asr** - anterior scale rows, **alt** - altitude, **at** - anterior temporal, **br** - broken, **co** - circumocular (**pro** - preocular + **so** - subocular + **po** – postocular + **spo** -supraocular), **db** -dorsal blotches, **ds** - dorsal scales, **f** – female, **il** - infralabials, **k** - keeled, **lo** - loreal (when 2 - one behind the other, when 3- two anterior and one posterior, when 4- two anterior and two posterior), **m** – male, **MCMZ** - Mendhar College Museum of Zoology (unique specimen identifier), **msr** - midbody scale rows, **pv** – photo voucher, **psr** - posterior scale rows, **pf** - prefrontals (**apf** - anterior prefrontal + **ppf** - posterior prefrontals), **sa** – subadult, **scd** -subcaudal, **sel** - secondary labials, **sl** - supralabials, **SVL** - snout-vent length, **TL** - tail length, **vent** - ventrals, **wk** - weakly keeled. If the left and right counts are different, they are separated by a slash.

		Meristic characters														**Morphometric characters**	
MCMZ	sex	asr	msr	psr	ds	vent	scd	pf	lo	co	sel	at	sl	il	db	SVL (mm)	TL (mm)
0619 *diadema/ atriceps*	sa	27	29	19	wk	248	106	7 (4+3)	2	8 (2+3+2 +1)	1	4/5	10/12	12	64	309	87
0719 *diadema diadema*	f	27	29	21	wk	244	106	8 (4+4)	2	9 (3+3+2 +1)	2	5	11/12	14	63	640	200
0819 *diadema diadema*	f	25	27	19	wk	249	96	7 (3+4)	2	9 (2+4+ 2 +1)	1	5	11	12/13	88	860	241
0514 *diadema diadema*	f	br	29	19	wk	241	102	5 (3+2)	2	9/8 (3+3+2+1/ 2+3+2+1)	2	4	11	13/14	54†	1130	340
PV0220 *diadema diadema*	m	26	29	19	wk	246	86	8 (4+4)	2	9 (2+3+3 +1)	2	5	11	12	60†	1280	230
0314 *diadema diadema*	f	25	29	19	wk	242	110	7 (4+3)	2/3	9/10 (3+3+2+1/ 3+3+3+1)	2	6	11/12	12	61	1203	384
0219 *diadema diadema*	m	26	29	19	wk	248	52 br	8 (4+4)	2	8 (2+3+2 +1)	1	4/5	11	13	62	1545	210
0413 *diadema diadema*	f	29	29	19	wk	234	111	7 (3+4)	3	9 (3+3+2 +1)	1	4	11	13	60	1340	450
PV0120 *diadema diadema*	m	26	29	19	wk	254	82	7 (4+3)	2	8 (2+3+2 +1)	2	5	11	12	64	1440	325
0119 *diadema cliffordii/ diadema*	m	26	29	19	wk	240	78	7 (4+3)	2	8 (2+3+2 +1)	1	4	11	11/12	85	1415	321
0920 *atriceps*	m	27	29	19	k	238	105	8 (4+4)	2	7/8 (2+2+2+1/ 2+3+2+1)	1/2	4/5	11	13	57‡	1110	285
1020 *atriceps*	f	28	31	21	k	250	109	7 (4+3)	3/4	9/11 (3+3+2+1/ 3+3+4+1)	2/2	4/6	12/13	13	nil	1230	333

† faded on the tail, not seen clearly; ‡ dull shades of blotches only.

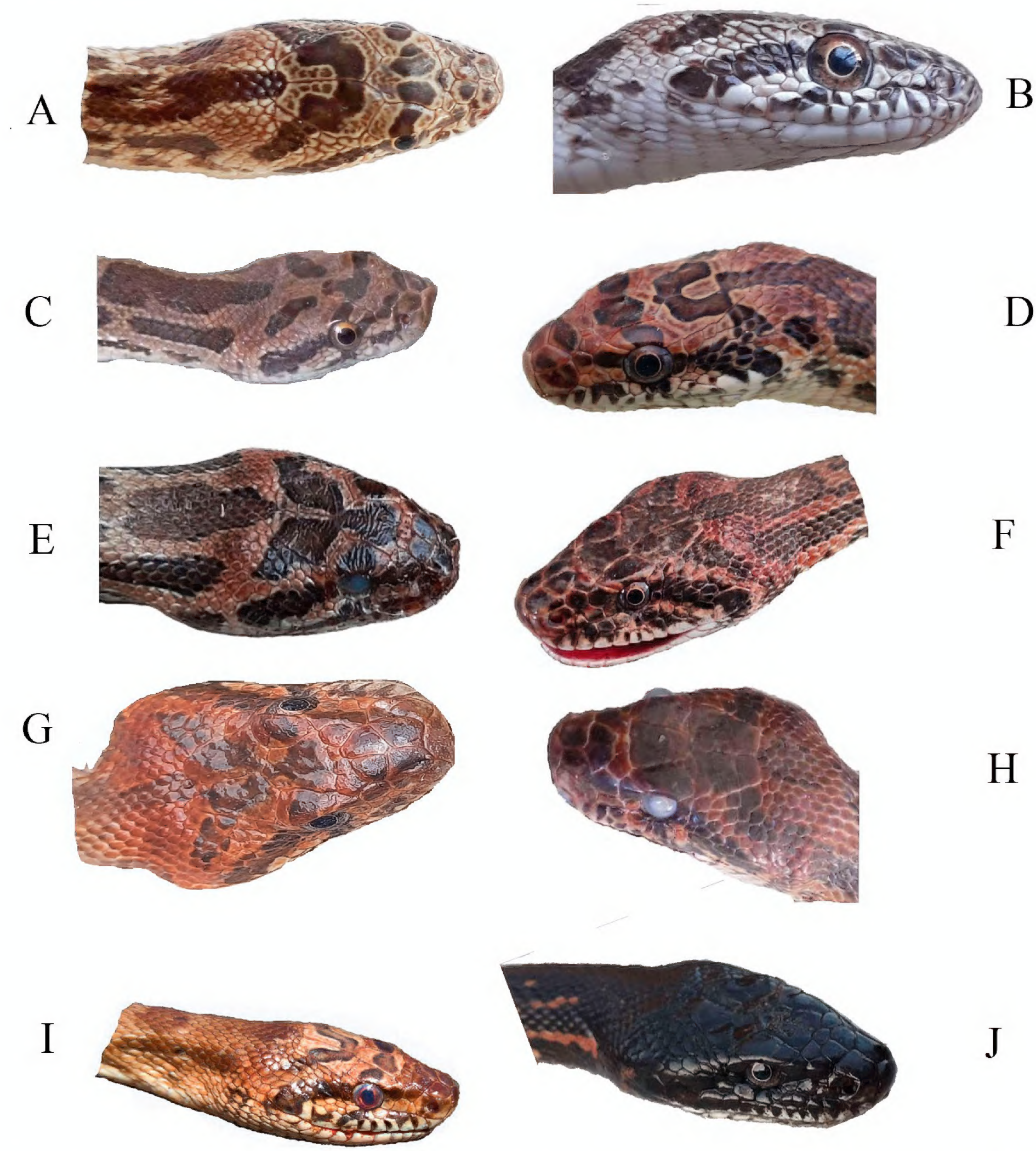

Figure 4. A-J. Colouration and dark markings of heads of *Spalerosophis* spp: subadult (**A, B.** MCMZ0619), *S. d. diadema* (**C.** MCMZ0719; **D.** MCMZ0819; **E.** Photo Voucher; **F.** MCMZ0219; **G.** Photo Voucher), *S. d. cliffordii/ diadema* (**H.** MCMZ0119) and *S. atriceps* (**I.** MCMZ0920; **J.** MCMZ1020).

Only three specimens of *S. atriceps* were encountered during the study period. One was alive and two were found killed. The live one was showing an exactly similar colour pattern as that of MCMZ1020 (Fig. 7B). The pattern of marking is quite variable in differently-aged individuals of *S. atriceps*. In the smaller-sized individual, the body is straw yellow with irregular black flecks restricted to few scales and faded dorsal blotches as if the snake had been spattered with tar, the head giving a pink hue and mottled with black marking similar to forma typica (Fig. 7A). These spots of *S. atriceps* differ from *S. diadema cliffordii/diadema* (Fig. 6C) in the manner that they are not present in rows and do not show any uniform pattern. A more grown individual of *S. atriceps* has a highly melanistic dark bluish to black body with few ruddy brown scales (Fig. 7B).

In *S. d. diadema*, the belly is whitish in all the half-grown specimens (Fig. 5A, B ventrals), but, in grown-up individuals, it is suffused with pink, especially in the middle line (Figs 5C, 6A ventrals) or there are frequently

greyish spots or mottling at the lateral edges of the ventrals (Fig. 6B ventral). The belly of *S. d. cliffordii/diadema* (Fig. 6C ventral) resembles that of *S. d. diadema* (Fig. 6B ventral), whereas, *S. atriceps* has a ruddy white or uniform rosy pink belly in younger (Fig. 7A ventral) and light black in fully grown individuals (Fig. 7B ventral).

The number of blotches vary a great degree from individual to individual. In the present study, the number of blotches remain countable (54–88) in all sizes of *S. d. diadema* and *S. d. cliffordii/diadema*, but remain observable only in the younger and moderately melanistic form of *S. atriceps* (Tables 1, 2). With little deviation from the two lateral rows of spots on each side of the body of adult forms, younger individuals have three rows of lateral spots on each side of the fore-body which are reduced to one or two rows on the tail (Fig. 5A).

Head markings. The head is light brown or copper colour or ruddy brown, variously spotted or mottled with dark spots in almost all the sizes of *S. d. diadema* (Figs 1B, 4 A-J) and *S. d. cliffordii/diadema* (Fig. 4H). The dark markings of the head are well distinct in younger forms, but become less distinct as age advances and this is true for both the species viz. *S. d. diadema* and *S. atriceps*. Markings of the head are often broken up, but the most constant is a band between the eyes, an oblique strip from behind the eye to the angle of the mouth and a quoit-like mark on the parietals (the diadem mark). The diadem mark is often connected with the band between the eyes by a median stripe (Fig. 4E–H) or remains quite detached (Fig. 4A–D, I) or throws back one to three short stripes posteriorly (Fig. 4A, D, F–I). Many departures from this arrangement may be seen either towards a confluence or a disintegration of these marks and, in many specimens, the interorbital and diadem marks are barely suggested (Fig. 4F, G, J). Smaller-sized individuals of *S. atriceps* have a light scarlet colour on the head and neck (Fig. 4I). Fully grown *S. atriceps* has a completely black coloured head (Fig. 4J). A very constant feature observed in all specimens of both the species is the presence of one light and one dark vertical band on each supralabial scale (Fig. 1B). This feature is so common that it is even retained by the intensely melanistic form of *S. atriceps* (Fig. 7B) where all the rest of the markings of the head are not visible.

Variation in mid-dorsal body blotches. In younger forms of *S. d. diadema*, the vertebral line of spots seems broken down into three spots: a median rhomboid large dark spot with a lateral slightly narrow band on each side. On the tail, a single narrow long mid-dorsal dark streak is present.

In older forms, the three small spots of vertebral line may become completely fused to form a single large rhomboidal dark spot (Figs 5B, 6A, C) or the median rhomboid remains distinct, but connected at its middle with two lateral smaller bands (Fig. 6B). In addition to this, the dorsal spots may fade away and may look quite dull, rendering them almost invisible (Fig. 5C). Similar to the pattern of younger individuals, the mid-dorsal spots on the tail of adult individuals may sometime fuse to form a single dark line at mid-dorsal position (Fig. 6B).

Table 2. The altitudinal range of occurrence along with a range of characteristics of *Spalerosophis diadema diadema*, *S. diadema cliffordii/diadema* and *S. atriceps*. Number in parenthesis are the number of specimens; means are in brackets; M=Male; F=Female. Different left and right counts are separated by a slash.

S.No	Characters	*S. d. diadema*	*S. diadema cliffordii/ diadema*	*S. atriceps*
1	Altitudes in metres	780–1920	990	1120–1630
2	Number of Individuals for meristic characters	8	1	2
3	Anterior Dorsal Scale Rows	25–29 (7)	26	27–28
4	Midbody Dorsal Scale Rows	27–29	29	29–31
5	Posterior Dorsal Scale Rows	19–21	19	19–21
6	Ventrals	234–249 F (5) 246–254 M (3)	240 M (1)	250F (1) 238M (1)
7	Subcaudals	96–111F (5) 82–86M (2)	78 M (1)	109 F (1) 105 M (1)
8	Prefrontals	5–8	7	7–8
9	Loreals	2–3	2	2–4
10	Circumocular	8–10	8	7–11
11	Secondary Labials	1–2	1	1–2
12	Anterior Temporals	4–6	4	4–6
13	Supralabials	10–12	11	11–13
14	Infralabials	11–14	11/12	13
15	Dorsal Blotches	54–88	85	57-Nil
16	Total length	840–1790 F (5)[1357.6] 1510–1765 M (3)[1752]	1736 M (1)	1563 F (1) 1395 M (1)
17	Tail Body Ratio	0.31 F 0.17 M	0.22 M	0.27 F 0.25 M

Variation in lateral body blotches. Lateral spots of the body in *S. d. diadema* form a complete dark blotch in the majority of the cases (Figs 5A, B, 6A, B), while sometimes, the lateral blotches may become faded from the inside, thus forming a dark ring on their margin (Fig. 5C). These lateral blotches are seen restricted to few scales only in *S. d. cliffordii/diadema* (Fig. 6C).

Morphometric and meristic characters

Scalation patterns and body sizes of *S. d. diadema*, *S. atriceps* and *S. d. cliffordii/diadema* are given in Tables 1, 2.

Loreals (Fig. 1). *Spalerosophis diadema diadema* and *S. d. cliffordii/diadema* have the same range of loreal count (i.e. 2–3), whereas *S. atriceps* differs in having a loreal scale range of 2–4. As far as the arrangement of loreals is concerned, when there are two, then they are positioned anterio-posteriorly in a single row; when three, they are partially arranged in two rows i.e. two are present anteriorly, positioned one above the other and one posteriorly and, when 4, two are present anteriorly and two posteriorly.

Prefrontals (Figs 1, 2). Scales in the prefrontal, range between 5–8 in *S. d. diadema* and *S. d. cliffordii/diadema* and 7–8 in *S. atriceps*. The lowest number of prefrontals are presented by MCMZ514 and the highest by MCMZ0719, MCMZ0219 and MCMZ0920. They are always found ar-

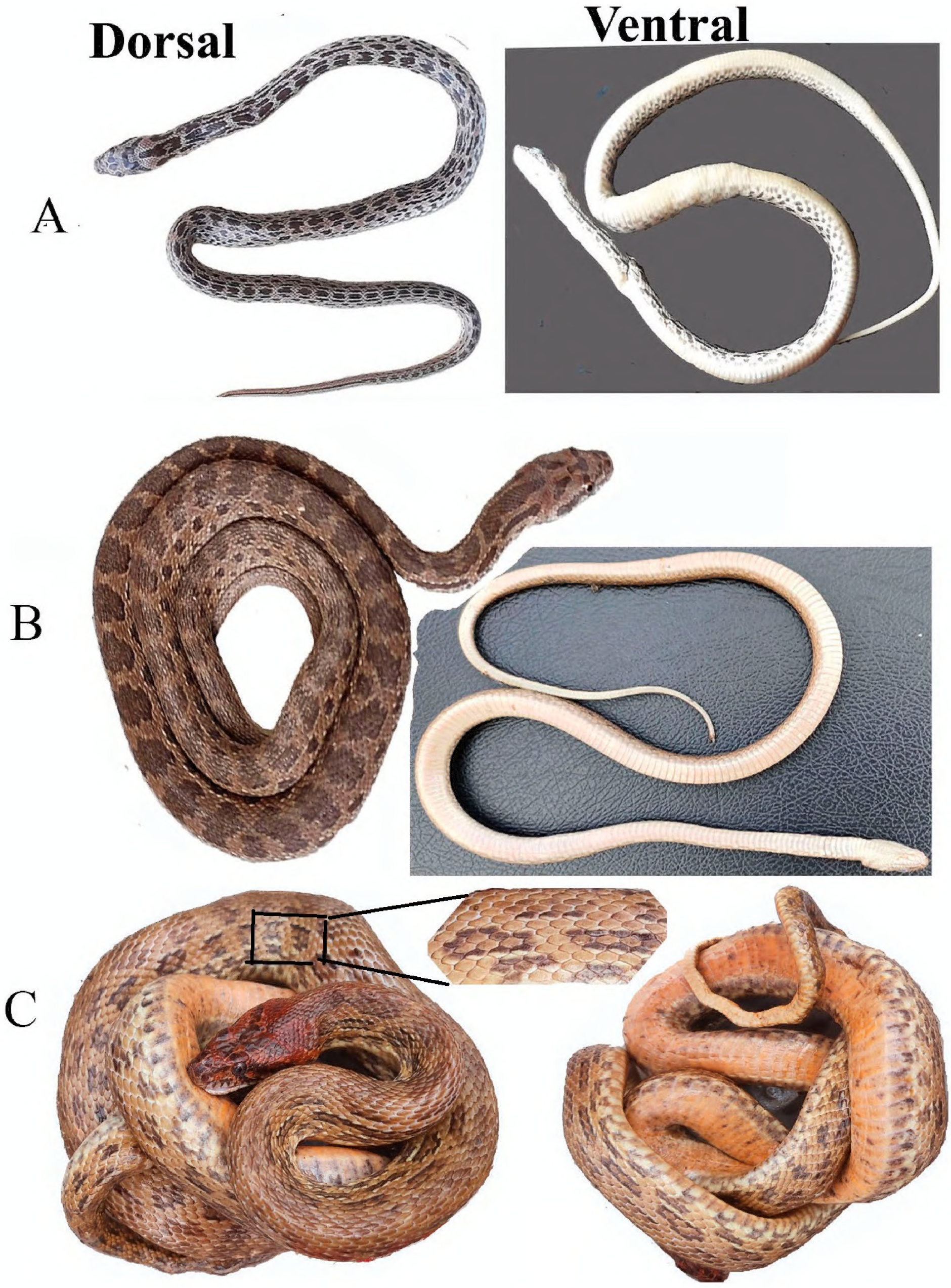

Figure 5. A–C. Dorsal and ventral view of *Spalerosophis* spp. **A.** Subadult (MCMZ0619) and **B.** Adult of *S. diadema diadema* (MCMZ0719). Both have uniformly white ventrals **C.** Adult *S. diadema diadema*. Photo Voucher showing fading of dark spots on the body.

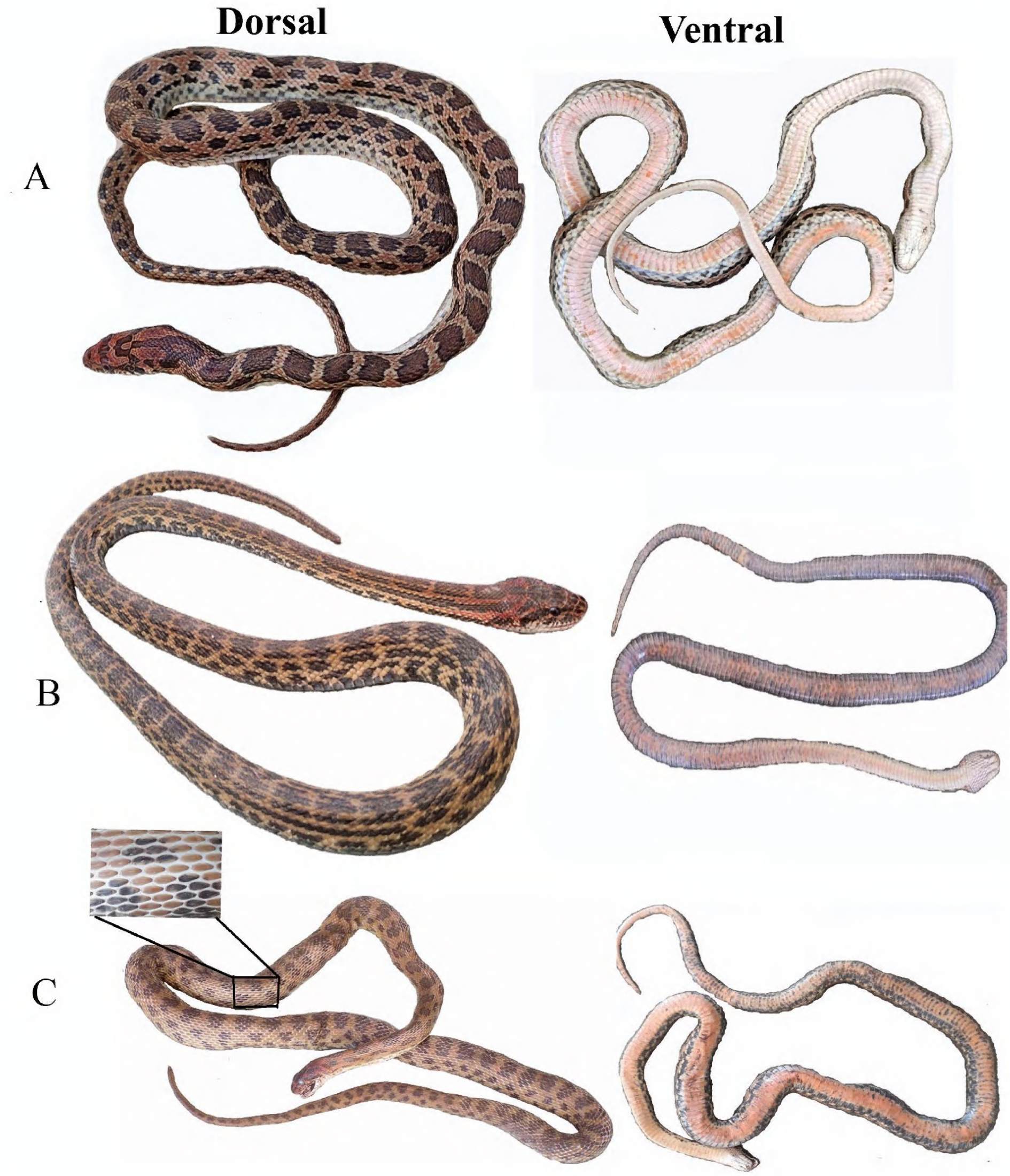

Figure 6. A-C. Dorsal and ventral view of adults of *Spalerosophis diadema diadema.* (**A.** MCMZ0819; **B.** MCMZ0219) and *Spalerosophis diadema cliffordii/ diadema* (**C.** MCMZ0119). Ventral scales of all are mottled with dark markings.

ranged in two rows, the anterior prefrontals and posterior prefrontals (Fig. 1A). Scales of both the rows show a variable size, shape and configuration. As shown in Table 1, the number of scales in the anterior prefrontal and posterior prefrontal rows may be 3–4 and 2–4, respectively. Scales of two rows may be restricted in their respective rows as depicted in specimen MCMZ0314 (Fig. 1) or one scale of the anterior prefrontal row may be so large that it touches the frontal scale directly as in MCMZ0119 and MCMZ0514 (Fig. 2A, C) or simply wide enough to restrict the number of anterior prefrontals to two as in MCMZ0819 (Fig. 2B).

Circumocular. The number of scales in the circumocular ring has a slightly lower range in *S. d. diadema* and *S. d. cliffordii/diadema* i.e. 8–10 scales than that of *S. atriceps* where this range is 7–11. This count includes 2–3 preocular, 2–4 postocular, 3–4 subocular and one large supraocular. The subocular scales completely separate the supralabials from the eye.

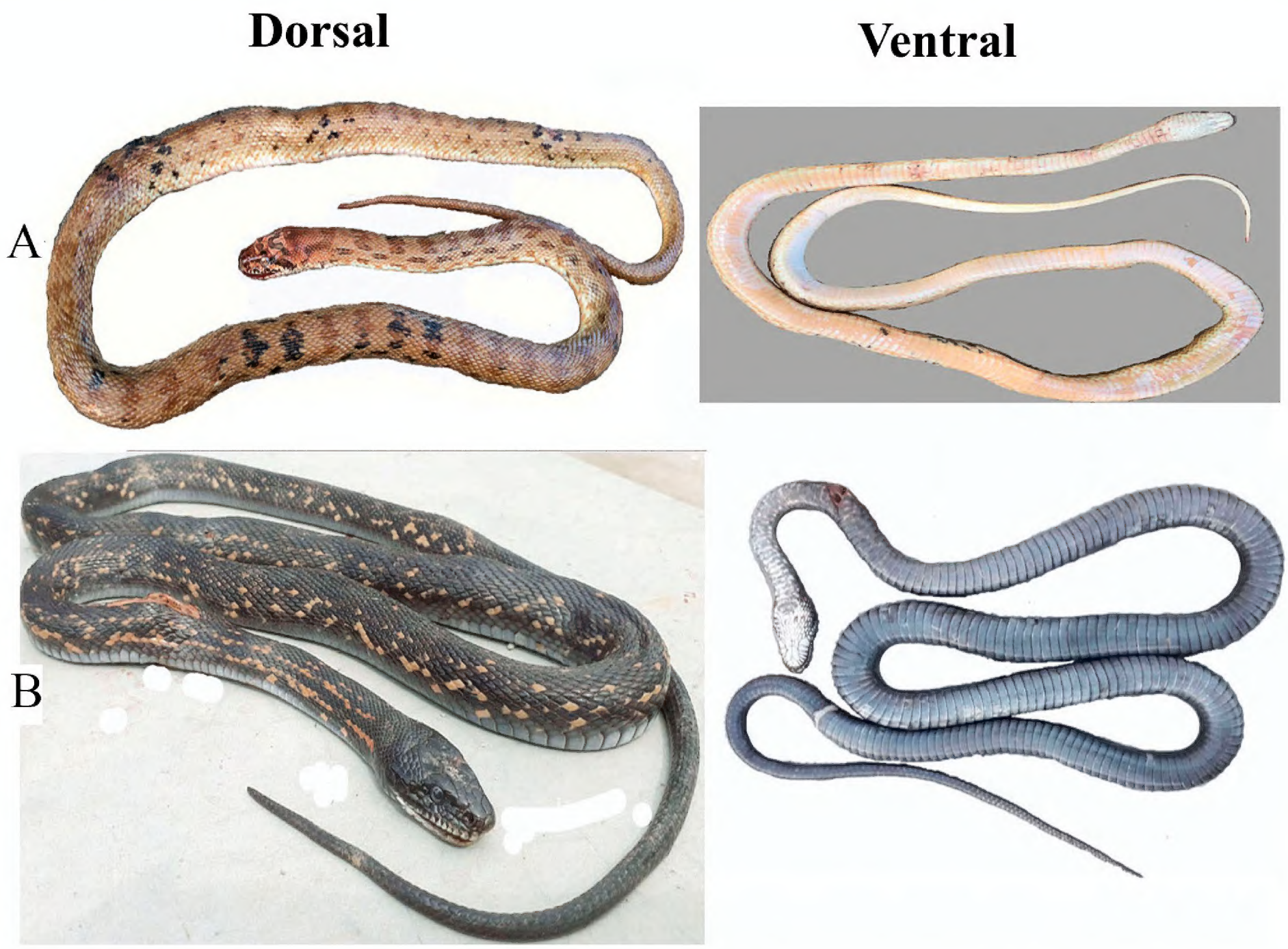

Figure 7. A, B. Dorsal and ventral view of *Spalerosophis atriceps*. **A.** Moderately melanistic, MCMZ0920 (Male); **B.** Intensely melanistic, MCMZ1020 (Female).

Labials. The count of supralabials and infralabials in *S. d. diadema* and *S. d. cliffordii/diadema* is in the range of 10–12 and 11–14, respectively. In *S. atriceps*, the supralabials count ranges between 11–13, whereas the infralabials count remains 13 for both individuals. The number of secondary labials ranges between 1 and 2 in *S. d. diadema* and *S. d. cliffordii/diadema* and between 0 and 2 in *S. atriceps*.

Temporals. Temporals range between 4 and 6 in all individuals.

Ventrals. Ventrals in males of *S. d. diadema* range between 246 and 254 and in females 234 and 249. The only male specimen of *S. d. cliffordii/diadema* reported in present study has 240 ventrals which are within the range of *S. d. diadema*. In the case of *S. atriceps*, ventral count is 238 in male and 250 in female. Anal is entire in all species.

Subcaudals. The number of subcaudals ranges between 96 and111 and 82 and 86 in females and males of *S. d. diadema*, respectively. The only male specimen of *S. d. cliffordii/diadema* reported in present study has 78 subcaudals which is lower than the lowest number of subcaudals count of *S. d. diadema*. In the *S. atriceps*, the subcaudal count of the female is within the range of *S. d. diadema* i.e. 109, whereas the male has a much higher number of subcaudals i.e. 105 as compared to the subcaudals count of males of *S. d. diadema*.

Dorsal scale rows. Dorsal scales are weakly keeled in *S. d. diadema* and *S. d. cliffordii/diadema*. In both of them, the count of rows of dorsal scales at the anterior (one head length behind the head), mid-body (at mid-ventral scale) and posterior (one head length ahead of anal) ranges between 25 and 29, 27 and 29 and 19 and 21, respectively. On the other hand, *S. atriceps* have keeled dorsal scales. The count of anterior and posterior dorsal scale rows of *S. atriceps* ranges between 27 and 28 and 19 and 21, respectively which is very much in the range of anterior and posterior dorsal scale rows of *S. d. diadema*, but the number of mid-body dorsal scales rows is again on the higher side i.e. 29–31 when compared with *S. d. diadema*.

Size. Males are smaller in size in both species. The maximum total length as reported in the present study is 1790 mm (tail 450 mm) for females and 1765 mm (tail 325 mm) for males of *S. d. diadema*. The total body length of the single male specimen of *S. d. cliffordii/diadema* is 1736 mm which lies within the highest range of size of the male of *S. d. diadema*. Though only one individual each of male and female has been reported for *S. atriceps*, the size of the male is again on the lower side (total length 1395 mm, tail length 285 mm) compared with that of the female (total length 1563 mm, tail length 333 mm). The tail/body-length ratio is 0.31 for females and 0.17 for males of *S. diadema diadema* and 0.27 and 0.25 for females and males of *S. atriceps*, respectively. The tail/body-length ratio of *S. diadema cliffordii/diadema* is 0.22.

Distribution (Fig. 3). Both the species of *Spalerosophis* viz. *S. d. diadema* and *S. atriceps* have shown sympatric distribution in the study area. *Spalerosophis diadema diadema* has shown a wider range of distribution as it has been reported from both temperate (tehsils (administrative regions) Surankote and Mandi) and sub-tropical regions (tehsils Haveli and Mendhar) of the study area within an altitudinal range of 780–1920 m, whereas *S. atriceps* has been reported from sub-tropical region (tehsil Mendhar) only within the altitudinal range of 1121–1633 m. The temperate zone of the study area has recorded less number of individuals of *S. d. diadema* as compared to the sub-tropical regions. Only a single specimen of *S. d. cliffordii/diadema* has been reported from a quite low altitude of tehsil Mendhar i.e. 990 m.

Habitat. *Spalerosophis diadema diadema* has been found in the crop field, crevices, bare area rocks, grass fields, mosaic vegetation and inside more often on the roof of a kaccha house (made of wood and soil) and walls. *Spalerosophis atriceps* has been reported from crop fields and bare rocky area. *Spalerosophis diadema cliffordii/diadema* has also been reported from a house. Vegetation of the areas under the report includes dispersed shrubs, annual grasses, maize and wheat crop fields and woody trees.

Activity and behaviour. The activity period of *Spalerosophis* spp. ranges between spring and autumn (May-October). Inside houses, *S. d. diadema* is found more active during the night-time. On two occasions, it was found coiled around a common house rat as if the latter were being killed by constriction. On being cornered, it suddenly raised its fore-body and glided sidewise in search of the escape route. On capturing, it expanded and contracted its body, produced a hissing sound and struck quickly. Younger ones are more active than adults. Out of the three specimens of *S. atriceps*, two were found dead in the field and the alive one was found basking in the sun after rain in the month of August and escaped before being captured. Similarly, the only single specimen of *S. diadema cliffordii/diadema* was found dead. Thus, we remain unable to gather details about the activity and behaviour of both *S. atriceps* and *S. d. cliffordii/diadema*.

Discussion

The study and identification of species is one of the first and most important steps to be taken before formulating a species-specific policy for the conservation of biological diversity. *Spalerosophis* spp. are adapted to a wide range of habitats (Rastegar-pouyani et al. 2008). As these species feed on some rodents, their role may be considered important in the biological control of the rodent population (Yadollahvandmiandoab et al. 2018). Present findings of reporting of *Spalerosophis* spp. from crop fields, kaccha houses and, on some occasions, wrapped around the common rat suggest the role of this species in rodent control.

Despite the observation on the distribution of *S. d. diadema* from the north-western parts of India i.e. Jammu and Kashmir, Punjab, Uttar Pradesh, Haryana, Rajasthan and Gujrat (Smith 1943; Sahi and Duda 1985; Sharma 2007), Baig and Masroor (2008) have restricted the distribution of *S. d. diadema* in the Indo-Pakistan region along the Pakistan border with Iran and Afghanistan only. In addition to this, Whitaker and Captain (2008, 2015), while describing the snakes of India, have not depicted *S. d. diadema* in the coloured plates and discussions. Sahi and Duda (1985) have mentioned the presence of *S. atriceps* from other districts of Jammu and Kashmir, but not from the Poonch District. Thus, the present study, besides re-validating the presence of *S. d. diadema* from the Poonch District, is also presenting a new record of *S. atriceps* from the study area.

Following Marx (1959), Schätti et al. (2009) considered *Spalerosophis diadema* as a polytypic species including *S. d. cliffordii* and *S. d. diadema*. Schmidt (1939) and Marx (1959) separated the *S. d. diadema* and *S. d. cliffordii*, based on the number of subcaudals, i.e. 80 or more in the former versus less than 80 in the latter. The present finding of one specimen MCMZ 0119 having a subcaudal count of 78 points to the likelihood of this specimen as the candidate of *S. d. cliffordii*. However, we refrain from this decision of establishing this species from the current study area and subject it to further investigations, based on the fact that none of the authors has ever reported *S. d. cliffordii* from India. Schätti et al. (2009) have shown the presence of *S. d. cliffordii* from the western Sahara to southwest Iran only. Moreover, Khan (2002, 2006) and Baig and Masroor (2008) have considered the subcaudals range of 78–114 for *S. d. diadema*. Thus, the establishment of *S. d. cliffordii* from this area needs more profound analysis, larger sample size and additional diagnostic characteristics.

Smith (1943), Marx (1959), Sharma (2007), Baig and Masroor (2008) and Whitaker and Captain (2008, 2015) reported that adults of *S. diadema* and *S. atriceps* show strikingly different head and dorsal colour patterns, but this does not hold true for subadults and juveniles, thus making their identification difficult. This also holds true in the present finding as a less grown individual of *S. atriceps* MCMZ 0920 is showing faded blotches and head markings as if the individual is losing its typical subadult markings of the head and body. Specimens MCMZ 920 having a SVL of 1110 mm showing a faded blotched pattern, as well as a moderately melanistic body and specimen MCMZ 1020 having SVL of 1230 mm exhibiting an intensely melanistic body, are identified as *S. atriceps* on the bases of the findings of Baig and Masroor (2008) who reported that *Spalerosophis atriceps*, on exceeding snout-vent length of 1000 mm, gradually loses the blotched pattern and changes into straw yellow colour with irregular flecks and blotches (Fig. 7A) and on attaining further growth changes to another melanistic form (Fig. 7B). In addition to this, the scalation pattern of these two specimens of *S. atriceps* as per our data are clearly in line with the earlier findings of Minton (1966) and Baig and Masroor (2008), mentioned hereinafter in brackets viz. mid-dorsals 29–31 [27–31 and 29–30]; ventrals 238–250 [232–254 and 230–252]; subcaudals 105–109 [96–114 and 100–112]. Thus, these two specimens are clear candidates for belonging to *S. atriceps*.

Specimens in the present study show little variation in the range of scales when compared with the findings of Wall (1914), Smith (1943), Marx (1959); Sahi and Duda (1985), Sharma (2007), Baig and Masroor (2008) and Whitaker and Captain (2008, 2015) and these variations may be ascribed to the different habitat of the present study area not explored earlier. Thus, the diagnostic key of *Spalerosophis* needs more inputs from its wide range of distribution areas as rightly pointed out by Schätti et al. (2009) that the systematic position of *Spalerosophis* has been subject to modifications over the past 140 years.

Body colour patterns as reported in smaller individuals of *Spalerosophis atriceps* (MCMZ 0920) having a yellowish-brown background with irregularly scattered dark brown or black spots either confined to individual scales or much more thickly distributed, forming large rhomboidal dorsal spots, similar in position to the dorsal larger-sized spots of *Spalerosophis diadema diadema* along with uniform rose pink belly (Fig. 7A) and colour pattern shown in the present study by the fully grown individual (MCMZ 1020) having an entirely black head with a deep red hue, which becomes deep red on nape and temples (Fig. 7B) are clearly in line with the findings of Smith (1943) and Sharma (2007) who have reported the occurrence of *S. atriceps* from Gilgit, Agra, Jeypore, Allahabad, Delhi and Harrand.

Though *Spalerosophis diadema diadema* and *S. atriceps* are sympatric species (Marx 1959), the latter is nocturnal in habit (Sharma 2007) and is uncommon (Whitaker and Captain 2015). Thus, the smaller number of individuals of *S. atriceps* found during the present investigations as compared to *S. diadema diadema* is probably because of the nocturnal habit and uncommon distribution of the former. In addition, low densities, elusiveness and long periods of inactivity are often the causes behind the low detection of the snake species (Seigel 1993) leading to underestimation of their distribution range compared with the other reptiles (Santos et al. 2006; Bombi et al. 2009)

Our findings of 54–88 dorsal blotches in *S. d. diadema* are very close to those of Baig and Masroor (2008) who have reported 56–84 dorsal botches from the Pakistan population of *S. diadema*. In our study, *S. d. cliffordii/diadema* has shown 85 dorsal blotches, whereas the blotches were absent in the fully melanistic form of *S. atriceps*. The number of blotches in the moderately melanistic form of *S. atriceps* has been counted up to 57 which is, again, in the range of the number of blotches as reported by Baig and Masroor (2008) i.e. 55–78 from Pakistan.

Arrangement of scales as observed in the present study, such as: (1) a complete ring of oculars in which suboculars are excluding the orbit from supralabials, (2) prefrontals and loreals broken up into small scales, (3) a high number of temporal scales and (4) an entire anal plate, are the diagnostic characteristics of *Spalerosophis* spp. (Marx 1959).

The number of ventrals showing sexual dimorphism in both species as observed in the present study (Table 2) is a diagnostic characteristic feature of *S. diadema* (Marx 1959; Schätti et al. 2010).

Keeled dorsals in *S. atriceps* and weakly-keeled dorsals in *S. d. diadema* as observed in the present findings have also been reported by Minton (1966) from Pakistan. Subadults have also shown weak keeling in the present study.

In our study, *S. atriceps* is showing a higher range of number of scales vis à vis *S. diadema diadema* [count of scales of *S. d. diadema* in brackets] in mid-body dorsal scales rows 29–31 [27–29], subcaudals 105–109 [82–111], loreals 2–4 [2–3], circumocular ring 7–11 [8–10] and supralabials 11–13 [10–12]. The count of scales of *S. atriceps* had also remained high in the findings of Baig and Masroor (2008) [count of *diadema* in bracket] for mid-body dorsal scales 29–30 [25–31], ventrals 230–252 [220–254] and subcaudals 100–112 [78–114]. Owing to a smaller number of individuals of *S. atriceps* in the present study, conclusions on the snout-vent length remain inconclusive and contrary to the findings of Baig and Masroor (2008) who have reported *S. atriceps* as larger-sized species as compared to *S. d. diadema*.

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Supplementary material 1

Threatening behaviour of *Spalerosophis diadema diadema*

Author: Sarshad Hussain

Data type: Video

Explanation note: It shows hissing and quick biting by *S. diadema diadema* in captivity.

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Link: https://doi.org/10.3897/herpetozoa.36.e94456.suppl1

Supplementary material 2

Table of localities

Author: Sarshad Hussain

Data type: Occurence

Explanation note: Showing latitude, longitude, altitude and name of the locality from where species of the genus *Spalerosophis* have been reported.

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Link: https://doi.org/10.3897/herpetozoa.36.e94456.suppl2